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(54) Discharge lamp with surrounding shroud and method of making such lamp.

(57) This discharge lamp includes (i) an inner envelope (12) of vitreous material comprising a bulbous portion (14) and two tubular portions (16, 18) extending from the bulbous portion and (ii) a tubular shroud (20) of vitreous material surrounding the bulbous portion and the two tubular portions. The lamp is made by the following method. A disk-shaped enlargement (30) is formed in at least one of the tubular portions by heating a localized region of the tubular portion to its softening point and then subjecting said localized region to a compressive force (i) that is abruptly applied along the length of the tubular portion and (ii) that drives the softened vitreous material radially outward into a disk formation. Then the tubular shroud is placed over the inner envelope so that each disk-shaped enlargement is positioned with its outer periphery closely adjacent the inner periphery of the surrounding tubular shroud. Then seals are formed between the outer peripheries of the disk-shaped enlargements and the surrounding shroud portions by heating each of the surrounding shroud portions to its softening point and collapsing it about the outer periphery of the associated disk-shaped enlargement.

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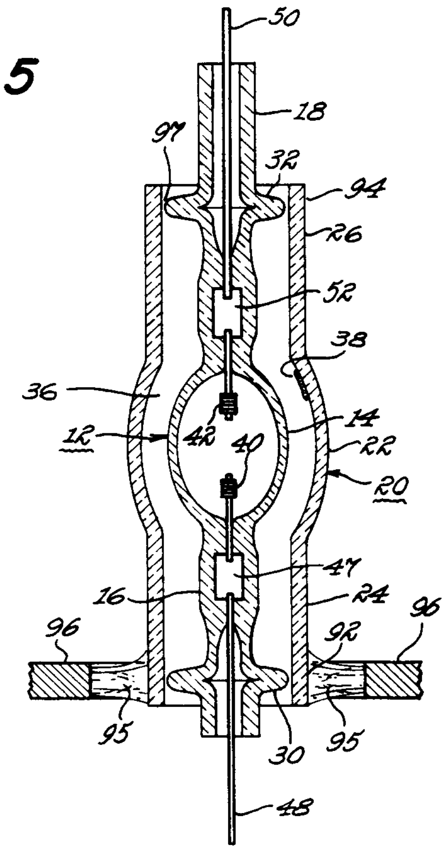
Fig. 5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This application is related to our U.S. Patent No 4935668 the disclosure in which is incorporated by reference in the present application.

This invention relates to a discharge-type lamp that includes an inner envelope and a shroud joined to the inner envelope and bounding a space surrounding the inner envelope. The invention also relates to a method of making such a lamp, particularly to a method of joining the shroud to the envelope.

The aforesaid US Patent discloses a metal-halide type discharge lamp that includes a quartz inner envelope and a tubular glass shroud surrounding the inner envelope and spaced therefrom along a portion of the shroud length. The tubular glass shroud is sealed at predetermined locations along its length to the inner envelope, and the space between the shroud and the inner envelope is evacuated or gas filled so that this space constitutes a sealed chamber. The shroud and the sealed chamber serve a number of important functions, which are pointed out and discussed in the aforesaid application. Generally speaking, one of these functions is to make the temperature of the inner envelope higher and more uniform, and another is to keep the shroud relatively cool in comparison to the inner envelope. The significance of these functions is discussed hereinafter and also in more detail in the aforesaid patent.

The ability to accomplish the results desired from the shroud and the vacuum chamber or gas chamber depends materially upon the nature of the joints or seals formed between the shroud and the inner envelope. For example, if we assume that (i) the inner envelope is of quartz and comprises an enlarged central region and tubular portions extending therefrom and (ii) the shroud is made of quartz tubing of inside diameter larger than that of the enlarged central region, which tubing is simply shrunk down upon these tubular portions of the inner envelope to form the two seals, then each seal will be constituted by a very thick region of quartz surrounding a substantial length of the tubular portion. To make such a seal requires a relatively large amount of heat applied for a relatively long time, followed by a relatively long cooling period; and, as a result, the thermal characteristics of this region are susceptible to being significantly changed by slight variations in the process of making the seals. These changes in thermal characteristics can detrimentally affect lamp performance. Moreover, the large amount of heat and the relatively long times involved in making such a seal can produce conditions that weaken, and possibly crack, the tubular inner-envelope portion at the seal.

Another disadvantage of making the shroud-to-inner envelope seals by simply shrinking down the shroud about the tubular portions of the inner envelope, as above described, is that using this approach will usually result in each of these shroud seals being located closely adjacent one of the foil seals of the lamp. These foil seals are used for providing a seal for the conductive inleads extending through the quartz of the inner envelope. If the shroud seal is closely adjacent the foil seal, there is an increased likelihood that the heat used for making the shroud seal will adversely affect the foil seal, possibly cracking the vitreous material in the foil seal region and possibly even causing a leak to develop in this region.

Simply locating the shroud-to-inner envelope seals at locations spaced further outwardly along the tubular portions of the inner envelope from the foil seals is not a satisfactory solution to these problems because the heat for making the shroud seals can cause oxidation of the nearby conductive inleads, and, moreover, this approach results in undesirably increasing the overall length of the lamp.

In one embodiment of our invention, we provide (i) an inner envelope comprising a hollow bulbous portion and two tubular portions of vitreous material extending from the bulbous portion and (ii) a tubular shroud of vitreous material surrounding the bulbous portion and said tubular portions. In each of the tubular portions of the inner envelope, we form a disk-shaped enlargement by first heating a localized region of the tubular portion to its softening point and then subjecting this softened localized region to a compressive force (i) that is abruptly applied along the length of said tubular portion and (ii) that drives the softened vitreous material radially outward into a disk formation. We then place the tubular shroud over the inner envelope so that each of the disk-shaped enlargements is positioned in alignment with a predetermined portion of the shroud and with the outer periphery of the enlargement closely adjacent but slightly spaced from the inner periphery of said predetermined shroud portion, thus forming an unsealed chamber between the shroud and the inner envelope and between the disk-shaped enlargements. We then form a first seal between the inner periphery of one of said predetermined portions of the shroud and the outer periphery of the aligned disk-shaped enlargement by heating and thereby softening said one predetermined shroud portion and then collapsing this shroud portion about the outer periphery of the aligned enlargement. We form a second seal between the inner periphery of the other of said predetermined shroud portions and the outer periphery of the disk-shaped enlargement aligned therewith.

The chamber referred to may be evacuated to a hard vacuum, or it may be filled with a suitable gaseous filler.

In still another embodiment, we provide the above-defined disk-shaped enlargement in only one of the tubular portions of the inner envelope, omitting the disk-shaped enlargement from the other tubular portion and forming a conventional seal between the other tubular portion and the surrounding portion of

the shroud aligned therewith.

For a better understanding of the invention, reference may be had to the following detailed description taken in connection with accompanying drawings, wherein:

Fig. 1 is a sectional view of a metal-halide discharge lamp embodying one form of the present invention. This lamp comprises an inner envelope of vitreous material and a tubular shroud of vitreous material surrounding the inner envelope.

Fig. 2 is a schematic illustration of one step used in making the inner envelope portion of the lamp of Fig. 1.

Fig. 3 shows the inner envelope portion of Fig. 2 after the fabrication steps depicted in Fig. 2 have been completed.

Fig. 4 illustrates the manufacture of an arc tube incorporating the inner envelope of Fig. 3.

Fig. 5 illustrates some of the method steps that are used for incorporating the shroud of Fig. 1 into the metal-halide lamp.

Fig. 6 is a sectional view of a metal-halide lamp embodying a modified form of the invention.

Fig. 7 is a sectional view of a vehicle head lamp that utilizes as its light source the lamp of Figs. 1-5.

Fig. 8 is a simplified sectional view of another modified form of the invention.

Referring now to Fig. 1, there is shown a metal-halide type of discharge lamp 10 that comprises an inner envelope 12 of a light-transmitting vitreous material, preferably quartz. The inner envelope 12 comprises a bulbous central portion 14 and two tubular portions 16 and 18 integral with the central portion 14 and projecting in opposite directions therefrom.

Surrounding the inner envelope 12 is a tubular shroud 20, also of a vitreous material, preferably quartz. This shroud 20 has an enlarged central portion 22 disposed about the central portion 14 of the inner envelope. Projecting from this enlarged central portion 22 are two tubular portions 24 and 26 respectively surrounding the tubular portions 16 and 18 of the inner envelope. Joining the shroud 20 to the inner envelope are two disk members 30 and 32 also of quartz. As will be explained in more detail, these disk members 30 and 32 are integral with the tubular portions 16 and 18 of the inner envelope and are joined at their respective outer peripheries to the surrounding regions of the shroud 20 to form vacuum-tight annular seals 33 and 35 between the disk members and the shroud.

The tubular shroud 20 is spaced from the inner envelope 12 in the region between the two disk members 30 and 32, thus providing a sealed chamber 36 surrounding the inner envelope 12 and having an exterior wall defined by shroud 20 and end walls defined by disk members 30 and 32. In one form of this invention, this sealed chamber 36 is evacuated to a hard vacuum during fabrication of the lamp in a manner that will soon be described. Preferably, this chamber includes a suitable getter 38 that is used in a conventional manner to assist in maintaining the hard vacuum in the chamber.

Within the inner envelope 12 are two spaced-apart electrodes 40 and 42 between which an electric arc is developed in a conventional manner to serve as a light source. The electrodes are preferably of tungsten or a mixture of tungsten and 1%-3% thorium oxide. The electrodes include rod portions 44 and 46, respectively, that extend outwardly from the gap between the electrodes into the tubular portions 16 and 18 of the inner envelope. At the outer end of rod portion 44 there is a foil member 47, preferably of molybdenum, joined to the rod portion 44; and extending outwardly from the foil member there is an inlead 48, preferably of molybdenum, that is joined at its inner end to the foil member. The foil member 47, the inlead 48, and the rod portion 44 of the electrode are of a conventional form, and they are joined together in a conventional manner. The surrounding vitreous material of the envelope portion 16, while hot and softened, is collapsed about the foil, rod, and inlead structure in a conventional manner (such as disclosed, for example, in U.S. Patent 4,891,551 - Ahlgren et al) to form a leak-proof seal between the foil member and the surrounding vitreous material. At the opposite, or right-hand, end of the arc tube there is a foil member 52 joined to an inlead 50 and to the rod portion 46 of electrode 42. These components are of the same form and composition as those at the left-hand end of the arc tube and are mounted within the surrounding vitreous material in the same way, a seal being present between the foil member and the surrounding vitreous material. The above-described inleads 48 and 50 and their associated foil members serve in a conventional manner to carry electric current to and from the arc, or discharge, that is present between the electrodes when the lamp is on.

In one embodiment of the invention, the central portion 14 of the inner envelope 12 contains a fill containing mercury, a metal halide, and in some cases xenon gas. The operating pressure of the fill is in the range of about 2 to about 65 atmospheres. This fill is described in more detail in US Patent 4935668. Typically, one of the principal components of the fill is sodium iodine.

As further pointed in US Patent 4935668, the evacuated chamber 36 acts to produce an improved wall temperature of the inner envelope 12 by substantially eliminating the effects of gas conduction and convection in the region surrounding the inner envelope. The presence of the evacuated chamber makes this wall temperature higher and more uniform. This results in more metal halide being vaporized and maintained in the arcing region, which improves the efficiency of the lamp and the color of the emitted light. In metal-halide lamps operating at low frequency, there is a catephoresis effect that tends to sweep the

metal halides into the end regions of the bulb (14), but in the illustrated lamp this effect is largely cancelled out by the higher temperatures produced in these end regions by the presence of the evacuated chamber 36 and its thermal insulating effect.

This thermal insulating effect enables us, through proper choice of the size of the shroud, to operate a shroud of reasonable size at a sufficiently low temperature that its electronic conductivity remains very low. Maintaining this low electronic conductivity allows any sodium ions which diffuse through the inner envelope and evaporate to settle on the inside wall of the shroud without being electrically neutralized by wall conduction. It is believed that this enables the settled sodium ions to produce a strong electrical field which opposes the motion of subsequent migrating sodium ions, thereby reducing any further related sodium loss.

For the evacuated chamber 36 to function consistently in the desired manner summarized above, it is important to construct the joints between the outer shroud (20) and the tubular portions (16 and 18) of the inner envelope in such a manner that the thermal characteristics of the lamp in the region of these joints are consistent and predictable from one lamp to another. If these joints had required for their fabrication high heat inputs maintained for long times, then small variations in the process for making them could produce undesirable large variations in the thermal characteristics of these regions of the lamp. We have developed a method for making these joints which can be performed with relatively little heat applied for relatively short times, thus materially reducing these undesirable variations.

The first step in our method is illustrated in Fig. 2, where the tubular blank 60 from which the inner envelope is formed is shown mounted within a conventional glass lathe schematically illustrated at 61. This lathe comprises a headstock 62 and a collet chuck 64 for mounting the left-hand end of the tubular blank on the headstock so that the left-hand end is fixed against axial motion but is rotatable about the central longitudinal axis 66 of the blank 60. The lathe further comprises a tailstock 72 and a collet chuck 73 for mounting the right-hand end of the blank 60. During lathe operation, the tailstock and the headstock are rotatably driven in synchronism about a common longitudinal axis coinciding with axis 66 by the same drive mechanism, thereby rotating the blank 60 about its longitudinal axis 66. In a conventional manner, the tailstock is also suitably mounted for selective movement parallel to this longitudinal axis 66, as indicated by the arrow 79.

Positioned adjacent the left-hand tubular portion 16 of the blank 60 is a burner 80 that is adapted to develop a flame 82 that can be directed as shown against an axially -localized region 83 of the tubular portion 16. While the blank 60 is being slowly turned about its axis 66 by the lathe, the flame 82 heats the axially-localized region 83 about the entire periphery of the tubular portion 83 until the quartz in this region 83 has reached its softening point. The tailstock remains stationary during such heating; but when the quartz in region 83 is sufficiently softened, the tailstock is abruptly moved a short distance to the left, as indicated by arrow 79. This abrupt leftward motion causes compressive force to be applied to the softened region 83 in a direction along the axis 66, and such force has the effect of driving the softened quartz in this region 83 radially outward about the entire periphery of the tubular portion 16, thereby producing the disk formation shown at 30 in Fig. 3. These heating and force-applying steps (sometimes referred to herein as an upsetting operation) can be readily controlled to consistently produce a disk formation of a predetermined outer diameter and a predetermined thickness along the length of axis 66.

The operations of the immediately-preceding paragraph are repeated with the burner in a position 86 shown in Fig. 2, thereby producing a second disk-shaped enlargement, shown at 32 in Fig. 3. The outer diameter of the disk-shaped enlargements 30 and 32 should not exceed the outer diameter of the arc chamber 14 so that the diameter of the shroud tube, which is later slipped over the arc chamber, may be minimized.

As a next step, the two electrodes 40 and 42 and their inlead structures are installed by first suitably positioning each of these electrodes and inlead structures as shown in Fig. 4. Then the surrounding quartz (in region 90) is heated to its softening point and is collapsed about the conductive structure. The result is a sturdy mount for the inlead and the electrode and a good leak-proof seal between the foil member 47 or 52 and the surrounding quartz. This sealing of the foil member and mounting of the electrodes and inleads is a conventional operation, which is disclosed in greater detail in our aforesaid U.S. Patent 4,891,551. The fill, described hereinabove, that is present in the arc chamber 14 of the lamp assembly of Fig. 1 is installed in a conventional manner after one of the foil seals is made as above described but before the other foil seal is made.

As a next step, the tubular shroud 20 is installed as shown in Fig. 5. This shroud is positioned about the inner envelope of Fig. 4 so that predetermined portions 92 and 94 thereof are in alignment with the disk-shaped enlargements 30 and 32, respectively. Each of the disk-shaped enlargements has been formed by the operation of Fig. 2 in such a manner that its outer diameter is almost, but not quite, as large as the internal diameter of the shroud 20 in the aligned regions 92 or 94. Accordingly, there is a small clearance space about the outer periphery of each of the enlargements that allows the shroud 20 to be readily positioned in the desired position shown.

After the shroud 20 has been so positioned, the region 92 of the shroud is heated by flame 95 derived from a ring-type burner 96 that surrounds the region 92. After a relatively short time, the quartz of region 92 reaches its softening point and begins to contract under the influence of surface tension. This causes the softened region 92 to collapse about the outer periphery of the aligned disk-shaped enlargement 30, which, because of its proximity, has also been heated by flame 95. When the softened shroud region 92 collapses about the outer periphery of the disk-shaped enlargement 30, an excellent seal is formed between shroud region 92 and the enlargement 30 about the entire outer periphery of the enlargement.

After the first seal is made at 92, the space 36 between the shroud 20 and the inner envelope 12 and between the disk-shaped enlargements 30 and 32 is evacuated. This is done by evacuating this space 36 with a suitable vacuum pump (not shown), which draws the contents of this space out through the small clearance space 97 surrounding the other disk-shaped enlargement 32. (The intake of the pump is connected in a conventional manner between the tubular portion 18 of the inner envelope and the surrounding tubular portion 26 of the shroud in a location above the enlargement 32.) While such evacuation is taking place, the walls of space 36 are suitably heated to help drive off absorbed gases. In a preferred form of the evacuation process, we alternately pump the space 36 and flush it with an inert gas, such as argon or nitrogen. The flushing gas is introduced through the clearance space 97 in the intervals between the pumping periods.

After space 36 has been evacuated in this manner to a hard vacuum, a seal is made between the outer periphery of the disk-shaped enlargement 32 and the surrounding region 94 of the shroud 20. This seal is made in essentially the same manner as was used for making the first seal (at 92). More specifically, the shroud region 94 is heated to soften it, thereby causing it to collapse about the outer periphery of the disk-shaped enlargement and form a seal therewith. Because a vacuum is then present in the chamber 36 and also in the region above enlargement 32, there is a pressure differential on opposite sides of the shroud wall which promotes such collapse of the shroud about disk-shaped enlargement 32.

To assure that a hard vacuum is developed and maintained within the chamber 36, we provide, in one form of the invention, a suitable getter 38 within chamber 36. This getter is introduced, preferably, before the shroud is assembled over the inner envelope. In one form of the invention, the getter comprises chips of zirconium-titanium alloy dispersed about the inner wall of the shroud. This material is a good getter for hydrogen.

The locations (83 and 86 of Fig. 2) chosen for forming the disk-shaped enlargements 30 and 32 are such that the enlargements do not interfere with sealing the foils 47 and 52 within the tubular portions 16 and 18 of the inner envelope 12. More specifically, the chosen locations 83 and 86 are spaced axially outward from the location of the foils. But this axial spacing is kept sufficiently small so that the presence of the enlargements does not add materially to the overall length of the shrouded lamp.

A significant feature of our shroud-to-inner envelope seals is that each seal is relatively remote from the foil seal at the same end of the envelope. In this respect, note in Fig. 1 that the shroud-to-inner envelope seal at each end of the lamp is located radially-outward of the foil seal at the same end of the lamp by a distance approximately equal to the radial dimension R of the associated disk-shaped enlargement 30 or 32. This remoteness of the shroud seal from the foil seal is advantageous because it materially reduces the chances that the foil seal will be detrimentally affected by the heat involved in making the shroud seal. It should also be noted that this remoteness between the two seals is achieved without materially increasing the overall length of the lamp since much of the separation between the two seals is in a radial direction rather than an axial direction. Some axial separation is, however,required so that the foil seal is located outside the axial boundaries of the associated disk-shaped enlargement.

Another significant advantage of our shroud-to-inner envelope seals is that they can be made with relatively little heat applied for only a short time. In this respect, it should be noted that because the disk-shaped enlargements 30 and 32 extend radially outward almost completely to the inner periphery of the tubular form of the shroud, as best shown in Fig. 5, only a slight displacement of the shroud radially inwardly is required in order to move the shroud material into contact with the portion of the inner envelope to which it sealed. Because the amount of this displacement is so small, very little heat and time is required to effect it, and thus the chances are substantially reduced that the lamp material in the vicinity of such seal will be detrimentally affected by the heat of the seal-making operation. This reduced heating cooperates with the remoteness features of the immediately-preceding paragraph further to protect the foil seals from any detrimental effects of the shroud-sealing operation.

Moreover, because we are able to make the shroud-to-inner envelope seals without requiring large amounts of heat and time, we have found that the process parameters are not critical. Minor variations in these parameters can be tolerated without significantly affecting the quality or characteristics of the resulting seal and the nearby lamp material.

Another significant advantage of our lamp and our method of making it is that the lamp can be readily and quickly made with automated equipment. For

example, formation of the disk-shaped enlargements (30 and 32) is effected with the simple heating and force-application steps depicted in Fig. 2. Such steps are readily performed on the same machine (lathe 61) that was used for forming the bulbous central portion 14 of the inner envelope, which central portion 14 is preferably formed in a conventional manner by heating the starting tubular blank in this region and blowing the heat-softened quartz radially outward. While the blank is on this same machine and in the same position, the disk-shaped enlargements 30 and 32 are introduced, as above described. In addition, the seals between the shroud and the inner envelope are made by simple and brief heating operations (Fig.5), which cause the heat softened regions of the shroud to collapse the short distances required to effect high-quality seals to the disk-shaped enlargements 30 and 32.

While the embodiment of Figs. 1-5 includes disk-shaped enlargements (30 and 32) provided at both ends of the lamp for making the shroud-to-inner envelope seals, some of the advantages of our invention can still be realized if an enlargement of this character is provided only at one end of the lamp. At the other end of such a lamp, the seal between the shroud and the inner envelope can be made in a conventional manner, for example, by allowing the heat-softened portion of the tubular shroud to shrink down to the tubular portion of the inner envelope that it seals to. Such a lamp is illustrated in Fig. 6, where this conventional seal, designated 100, is shown at the left-hand end of the lamp. To facilitate the making of seal 100, the tubular portion 24 of the shroud on the left hand end of the shroud is made only slightly larger than the left-hand-end tubular portion 16 of the inner envelope. The shroud is then slipped onto the inner envelope from the left hand end of the inner envelope so that the larger diameter end of the shroud slips over the bulbous portion 14 of the inner envelope and the disk enlargement 32. Then the seal 100 is made in a conventional manner.

One type of lamp where the approach of Fig. 6 is useful is one in which a surface of the shroud is coated with a reflective material to form a reflector which can be located close to the lamp. Such reflective material is indicated at 102 in Fig. 6. At the right-hand side of this lamp the shroud-to-inner envelope seal is the same as in Fig. 1. At the left-hand side of the lamp, the conventional seal 100 of the immediately-preceding paragraph is present.

In a preferred embodiment of the lamp, the inner envelope and the shroud are both of identical quartz. But our invention in its broader aspects contemplates the use of other vitreous material capable of withstanding the high temperatures developed by operation of the arc tube. It is usually very desirable to use the same material for the shroud and the inner envelope to avoid cracking or sealing problems that might arise because of different coefficients of thermal expansion of two different fused-together materials. But minor differences in the two materials can often be tolerated. For example, in another embodiment of our invention, we utilize for the shroud quartz which has been heated with a high electric field applied thereto to remove any traces of sodium which can increase electronic conductivity. Such high resistance quartz is available from General Electric Company as its sodium-free quartz. This high resistance quartz can be sealed to an inner envelope of ordinary quartz without encountering significant problems of differential thermal expansion. The presence of such high resistance quartz in the shroud is believed to help block sodium loss through the inner envelope.

The lamps described hereinabove are especially suited for forward lighting applications in a vehicle, such as an automobile, truck, bus, van or tractor. The aforesaid U.S. Patent 4935668 discloses several different ways in which a lamp of this general type is utilized for such forward lighting, and the present lamps are utilizable in the same ways. For example, referring to Fig. 7 of the present application, our lamp is shown at 10 within an automobile headlamp 110. This headlamp comprises a reflector 112, a lens member 114 at the front of the reflector, and lamp 10 in the space between the reflector and the lens.

The reflector 112 has a rear section 118 having mounted thereon a connector 120 with rearwardly-projecting prongs 122 and 124 capable of being connected to an external electrical source of the vehicle. The reflector 112 has a focal point 126 on the axis 128 of the headlamp. The light source 10 is predeterminedly positioned within the reflector 112 so that its mid-portion approximately coincides with the focal point 126 of the reflector. In the embodiment illustrated in Fig. 7, the light source 10 is oriented with its longitudinal axis extending vertically and in a transverse manner relative to the axis 128 of the headlamp.

In one embodiment, the reflector 112 has a parabolic shape with a focal length in the range of about 6 mm to about 35 mm, with a preferred range of about 8 mm to about 30 mm. The lens 114, which is suitably mated to the front portion of the reflector, is of a transparent material, such as glass or a suitable plastic. The lens has a rear face preferably formed of prism members.

The light source 10 is connected to the rear section of the reflector 112 by means of relatively heavy support wires 134 and 136 each having one end connected to one of the inleads 48 or 50 of the light source and its other end connected to one of the prongs 122 or 124. The light source 10 is energized via an electrical circuit that extends in series through the prongs and the support wires.

While in the lamps described hereinabove, the chamber 36 between the inner envelope and the shroud is evacuated to a hard vacuum, it should be understood that our invention in its broader aspects

comprehends lamps of essentially the same structure as shown in Figs. 1 and 6 except including in the chamber 36 a gas having appropriate properties. For example, in certain lamps it is desirable that a predetermined portion of the heat developed by operation of the arcing tube be transferred across the chamber 36 by conduction or convection rather than primarily by radiation, as when a hard vacuum is present. With this consideration in mind, the chamber 36 can be filled with one of the following gases or mixtures thereof: argon, krypton, xenon, nitrogen, air, helium, and hydrogen. Typical charging pressures are in the range of 0 to 1500 torr.

While in making the lamp of Fig. 1 we prefer to evacuate (or fill) the chamber 36 through one of the seal locations (e.g.,35) before a seal is made at this location, our invention in its broader aspects comprehends the use of a separate sealable tube (such as shown in Fig. 8 at 105) extending into this chamber through which the chamber may be evacuated and/or filled. When such a separate tube is used, we complete the seals at 33 and 35 before evacuting (or filling) the chamber through the separate tube. Then the separate tube 105 is pinched off or otherwise sealed in a conventional manner to seal the chamber 36.

While we prefer to form the disk-shaped enlargements 30 and 32 before the electrodes 40, 42 and their inlead structures are incorporated in the arc tube, the invention in its broader aspects contemplates forming these enlargements after the electrodes and their inlead structures are incorporated and before the shroud 20 is installed.

Summarising the foregoing, there has been described a form of discharge lamp in which a high quality seal between the inner envelope and the surrounding shroud can be quickly made with very little heat. The lamp is constructed in such a manner that the inner envelope-to-shroud seals are located remote from the foil seals yet without adding materially to the overall length of the lamp. Moreover the thermal characteristics of the lamp in the region of these seals are relatively unaffected by slight variations in the process of making the seals. Also described has been an improved method for making a vacuum-tight seal or gas tight seal between the inner vitreous envelope of a metal-halide discharge lamp and the surrounding shroud of vitreous material, the improved method enabling the seal to be made quickly and with very little heat. Also the resultant seal is located relatively remote from any other seals in the lamp, e.g. from any foil seal at the same end of the lamp. The improved method readily lends itself to being performed with automated equipment.

While we have shown and described particular embodiments of our invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from our invention in its broader aspects.

Claims

1. A method of making a discharge lamp that comprises (i) an inner envelope comprising a hollow bulbous portion of vitreous materal and two tubular portions of vitreous material joined to and extending in opposite directions from said bulbous portion and (ii) a tubular shroud of vitreous material surrounding said bulbous portion and said tubular portions, the method comprising:
   (a) forming a disk-shaped enlargement in each of said tubular portions by heating a localized region of the tubular portion to its softening point and then subjecting said softened localized region to a compressive force (i) that is abruptly applied along the length of said tubular portion and (ii) that drives the softened vitreous material radially outward into a disk formation,
   (b) placing said tubular shroud over said inner envelope so that each of said disk-shaped enlargements is positioned in alignment with a predetermined portion of said shroud and with the outer periphery of the enlargement closely adjacent but slightly spaced from the inner periphery of said predetermined shroud portion, thereby forming an unsealed chamber between said shroud and said inner envelope and between said disk-shaped enlargements,
   (c) forming a first seal between the inner periphery of one of said predetermined portions of the shroud and the outer periphery of the disk-shaped enlargement aligned therewith by heating and thereby softening said one predetermined shroud portion and then collapsing said one predetermined shroud portion about the outer periphery of said aligned enlargement,
   (d) forming a second seal between the inner periphery of the other of said predetermined shroud portions and the outer periphery of the disk-shaped enlargement aligned therewith.

2. A method as defined in claim 1 and further comprising the step of evacuating said chamber.

3. The method of claim 2 in which the evacuation step is carried out by causing flow to occur through a clearance space present between the outer periphery of said other disk-shaped enlargement and the inner periphery of the other of said predetermined shroud portions before said second seal is formed.

4. A method as defined in claim 1 and further comprising the step of filling said chamber with a gaseous fill.

5. The method of claim 4 in which said filling step is carried out by causing flow to occur through a clearance space present between the outer periphery of said other disk-shaped enlargement and the inner periphery of the other of said predetermined shroud portions before said second seal is formed.

6. The method of claim 1 in which said second seal is formed by heating and thereby softening said other predetermined shroud portion and then collapsing said other predetermined shroud portion about the outer periphery of said other enlargement.

7. A method of making a discharge lamp that comprises (i) an inner envelope comprising a hollow bulbous portion of vitreous material and two tubular portions of vitreous material joined to and extending in opposite directions from said bulbous portion and (ii) a tubular shroud of vitreous material surrounding said bulbous portion and said tubular portions, the method comprising:

(a) forming a disk-shaped enlargement in one of said tubular portions by heating a localized region of the tubular portion to its softening point and then subjecting said softened localized region to a compressive force (i) that is abruptly-applied along the length of said tubular portion and (ii) that drives the softened vitreous material radially outward into a disk formation,

(b) placing said tubular shroud over said inner envelope so that said disk-shaped enlargement is positioned in alignment with a first predetermined portion of said shroud and with the outer periphery of the enlargement closely adjacent but slightly spaced from the inner periphery of said first predetermined shroud portion, and

(c) forming a joint between the inner periphery of said first predetermined portion of the shroud and the outer periphery of the disk-shaped enlargement aligned therewith by heating and thereby softening said first predetermined shroud portion and then collapsing said first predetermined shroud portion about the outer periphery of said aligned enlargement.

8. A method as defined in claim 7 in which said tubular shroud when placed over said inner envelope includes a second predetermined portion surrounding the other of said tubular portions of said inner envelope, the method further comprising forming a second joint between said second predetermined shroud portion and said other tubular portion of said inner envelope.

9. The method of claim 8 in which said two joints constitute seals for a chamber located between said shroud and said inner envelope and between said disk-shaped enlargement and said second joint, the method further comprising the step of evacuating said chamber.

10. The method of claim 8 in which said two joints constitute seals for a chamber located between said shroud and said inner envelope and between said disk-shaped enlargement and said second joint, the method further comprising the step of filling said chamber with a gaseous fill.

11. A metal-halide discharge lamp comprising:

(a) an inner envelope comprising:

(a1) a hollow bulbous portion of vitreous material containing a fill including a metal halide,

(a2) two tubular portions of vitreous material joined to and extending in opposite directions from said bulbous portion,

(a3) a disk-shaped enlargement on one of said tubular portions of the same vitreous material as said one tubular portion projecting radially outward from said one tubular portion and integral therewith, and

(b) a tubular shroud of vitreous material surrounding said inner envelope and having a predetermined portion surrounding and aligned with said disk-shaped enlargement, said predetermined shroud portion being collapsed about the outer periphery of the disk-shaped enlargement aligned therewtih and forming a joint with the outer periphery of said disk-shaped enlargement.

12. The lamp of claim 11 in which said predetermined shroud portion forms a seal with the outer periphery of said disk-shaped enlargement, and in which said shroud constitutes an outer wall and said disk-shaped enlargement constitutes an end wall of a chamber surrounding the tubular portions and the bulbous portion of said inner envelope.

13. The lamp as defined in claim 11, comprising

(a) a disk-shaped enlargement on each of said tubular portions of the same vitreous material as the associated tubular portion projecting radially outward from said associated tubular portion and integral therewith,

(b) said tubular shroud having predetermined portions respectively aligned with and collapsed about the outer periphery of the disk-shaped enlargement, and in which:

(c) said shroud constitutes an outer wall and said disk-shaped enlargements constitute

end walls of a chamber surrounding the tubular portions and the bulbous portion of said inner envelope.

14. A lamp as defined in any one of claims 11 to 13 and further comprising:

(a) a pair of spaced-apart electrodes within said bulbous portion of said inner envelope, said electrodes having rod portions respectively extending from said bulbous portion into said tubular portions of the inner envelope and supported by the vitreous material of said tubular portions,

(b) two conductive inleads respectively projecting into said tubular portions of the inner envelope from outside the inner envelope,

(c) a foil member within each tubular portion of the inner envelope electrically connecting the associated inlead and the associated electrode rod portion, the vitreous material of said tubular portion being sealed to said foil member therein to form a foil seal, and

(d) said disk-shaped enlargement(s) being located axially outward of said foil seal(s).

15. The lamp of anyone of claims 11 to 14 in which each of said disk-shaped enlargements is the product of an upsetting operation performed on its associated tubular member, the upsetting operation comprising heating a localized region of the tubular portion to its softening point and then subjecting said softened localized region to a compressive force (i) that is abruptly applied along the length of said tubular portion and (ii) that drives the softened vitreous material radially outward into a disk formation.

16. The lamp of any one of claims 11 to 15, in which said inner envelope and said shroud are of quartz, the quartz of said shroud having a substantially lower electronic conductivity than that of the inner envelope.

17. The lamp of any one of claims 11 to 16, in which:

(a) said fill includes a sodium halide, and

(b) said shroud is sufficiently large that the shroud temperature remains low enough during lamp operation to substantially prevent sodium loss from the inner envelope.

18. A vehicle headlamp comprising:

(a) a reflector,

(b) a lens at the front of the reflector, and

(c) a lamp as defined in any one of claims 11 to 17, mounted in a position between said reflector and said lens.

Fig.1

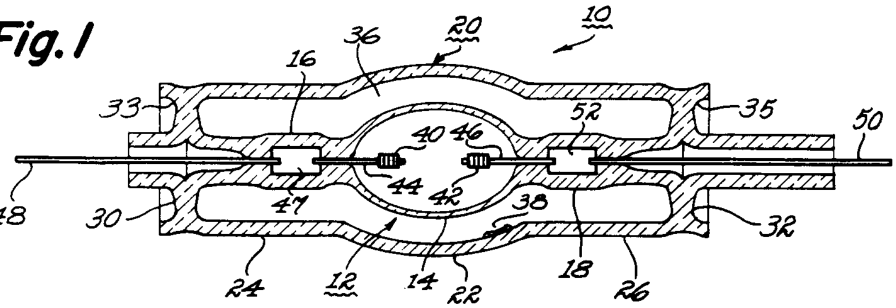

Fig.2

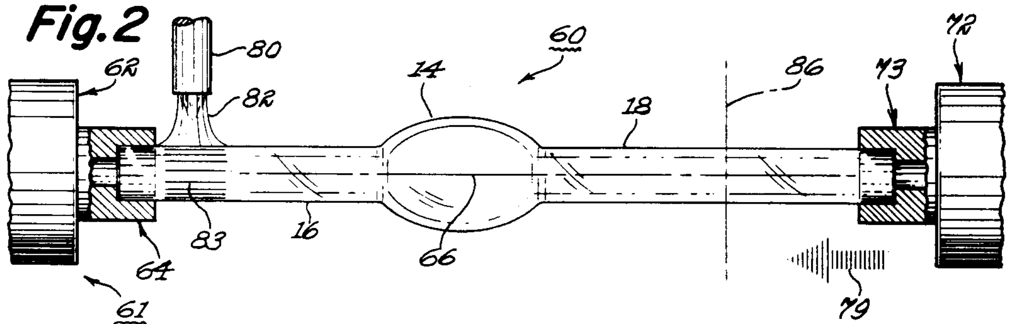

Fig.3

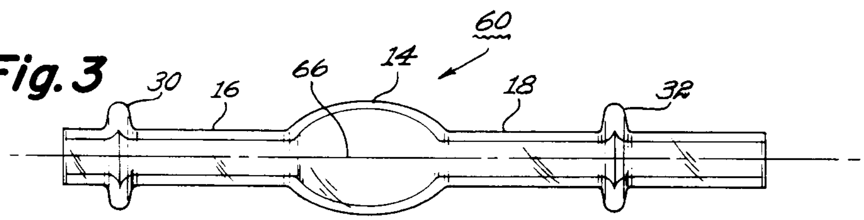

Fig.4

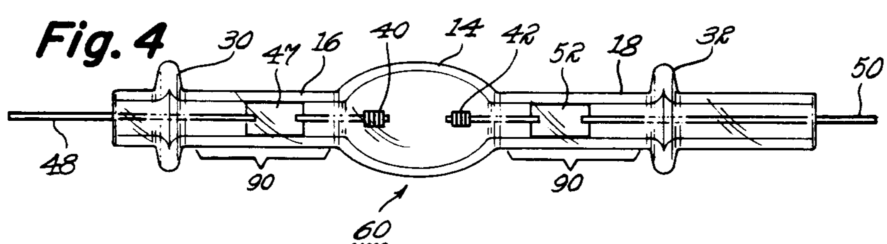

Fig. 5

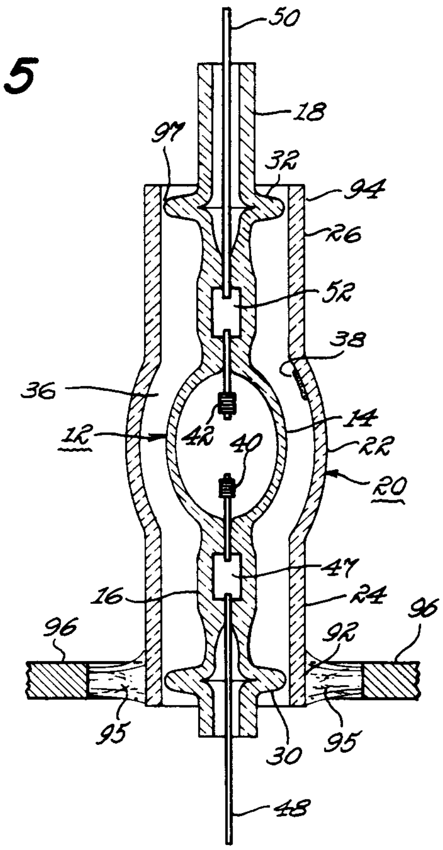
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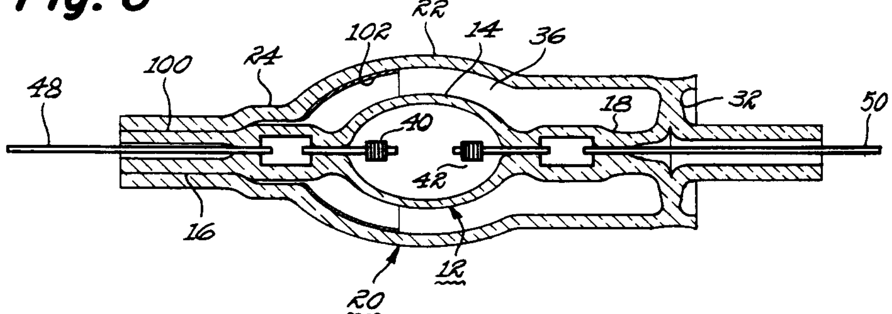
Fig. 6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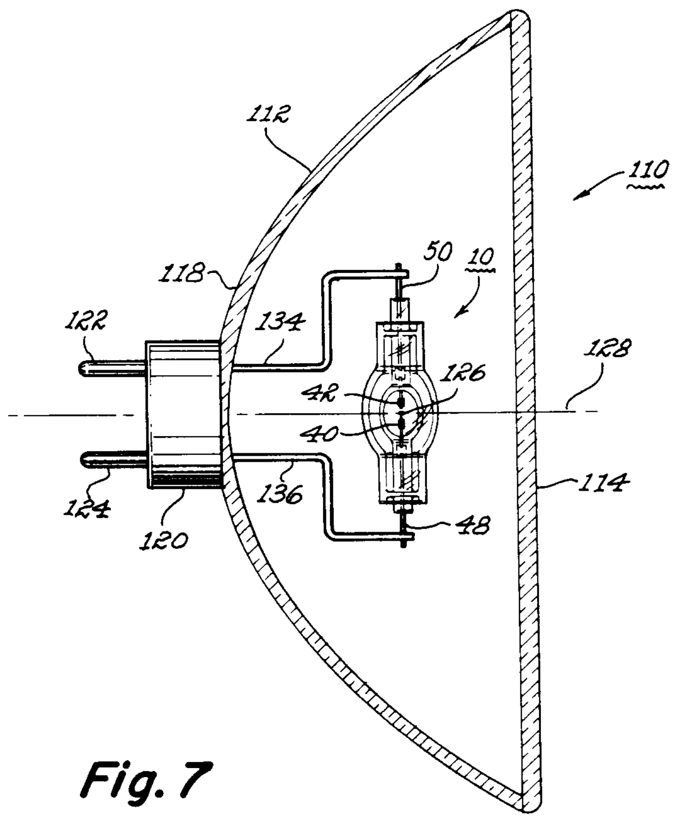
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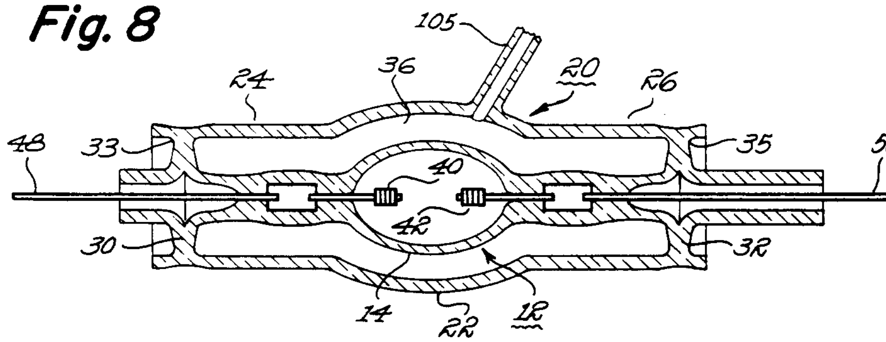
Fig. 7

Fig. 8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